The Current State of Recordable DVD Media Formats

CD-R and -RW continue to be the most widely used removable storage technology because of the extremely low cost of drives, players and media. However, with prices for DVD hardware and media dropping, the DVD recordable formats are rapidly gaining acceptance for use in document, video, audio and personal/professional storage.

The prime selling points of DVD are its inherent reliability and massive data storage capabilities--ultimately up to 9.4GB of removable storage with a double-sided disc.

According to Wolfgang Schlichting, IDC's Research Manager, Removable Storage, 2002 will be the year when many consumers will discover the benefits of DVD recording. IDC projects that worldwide DVD media sales will climb from 50 million discs in 2002 to nearly 150 million in 2004.

There are basically two markets for recordable DVD: computer storage and A/V recording. While all of the format developers have focused on providing a single format that will work for both video and computer applications, each DVD format has its strengths and weaknesses

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Applications

All DVD media formats share common parameters for use in a wide range of personal and professional applications. The discs look very similar; however, they do not all work in every DVD drive, DVD-Video player or DVD recorder.

DVD Format Feature Comparison

Format	Write Speed	Read Compati-bility	Random Write	Defect Mgmt.	Rewrites
DVD-R	2X	Excellent	No	No	-0-
DVD+R	2.4X	Excellent	No	No	-0-
DVD-RW	1X	Good	No	No	1,000
DVD+RW	2.4X	Good	Yes (as option)	Yes (by drive)	1,000
DVD-RAM	2X	Poor	Yes	Yes (on disc)	100,000

While the DVD formats have important technical differences, the charts below have been developed to help content developers and users determine which media is best for them.

General Format Discussion

DVD-R, a recordable version of DVD-ROM - The DVD Forum has developed specifications for two write-once DVD-R categories - Authoring and General use. Although both types of DVD-R media can be read by nearly all DVD drives and players, technical differences make it impossible to write to DVD-R Authoring media using a consumer DVD-R General system and vice versa. DVD-R General recorders use a 650 nm recording laser wavelength while DVD-R Authoring use a 635 nm laser. In addition, the General Use media contains content protection technology to prevent users from making bit-for-bit copies of CSS- encrypted entertainment titles.

DVD-R for Authoring was designed to meet the needs of professional content developers and software producers. The media is primarily used to create master discs that will be mass produced by software houses, multimedia/video post-production facilities and archiving.

DVD-R for General Use was developed for business and consumer applications - data archiving and one-time video recording. Delivering 2X write performance, which is equivalent to an 18x CD write speed, the media provides secure recording for volumes of information that cannot be accidentally or intentionally altered. The low storage cost, 100-year data life and broad compatibility also make DVD-R General media ideal for small-scale distribution of DVD content. DVD-R general discs can be played back by the vast majority of the DVD-ROM drives and video players in use today. Available with street prices as low as $5.00, the media can be used by DVD-R General drives from Pioneer, Apple, Compaq, Sony, Panasonic and other leading manufacturers

DVD Media Specifications

	DVD-R Authoring	DVD-R General 4.7/9.4GB	DVD+R	DVD-RW	DVD+RW 4.7/9.4GB	DVD-RAM 4.7/9.4GB
Capacity	4.7 GB	4.7 GB/side	4.7 GB	4.7 GB	4.7 GB/side	4.7 GB/side
Laser Wavelength	635nm	650nm	650nm	650nm	650nm	650nm
Numerical Aperture	0.6		0.6	0.6	0.65	0.6
Recording Layer	Dye		Dye	Phase-Change	Phase-Change	Phase-Change
Reflectivity	45-85%		45-85%	18-30%	18-30%	15-25%
Modulation Amplitude	0.6 min.		0.6 min.	0.6 min.	0.6 min.	0.4 min.
Data Track Form	Wobbled groove + Land pre-pit		Phase modulated wobbled groove	Wobbled groove + Land pre-pit	Phase modulated wobbled groove	Wobbled land & groove + Pre-pit
Track Pitch	0.74µm		0.74µm	0.74µm	0.74µm	0.615µm
Tracking Method (reading)	DPD		DPD	DPD	DPD	DPD
Min. Pit Length	0.40µm		0.40µm	0.40µm	0.40µm	0.420µm
Data Modulation	8/16, RLL(2,10)		8/16, RLL(2,10)	8/16, RLL(2,10)	8/16, RLL(2,10)	8/16, RLL(2,10)
Error Correction	RS-PC		RS-PC	RS-PC	RS-PC	RS-PC
Channel Bit Rate	26.16Mbps		26.16Mbps	26.16Mbps	26.16Mbps	58.36Mbps
Scanning Velocity	3.49 m/s		3.49 - 8.44 m/s	3.49 m/s	3.49 - 8.44 m/s	8.16 - 8.49 m/s
Rewritability	N/A		N/A	1,000	1,000	100,000
Copy Protection	None	CSS	CSS	CSS, CPRM	CSS	CSS, CPRM

DVD+R - The write-once DVD+R specification is an extension of the DVD+RW format supported by the DVD+RW alliance: HP, Philips, Ricoh, Sony, Yamaha, Verbatim/Mitsubishi Chemical, Dell and Thomson. Similar in functionality and compatibility to DVD-R General, DVD+R was designed to provide widespread playback on DVD-ROM drives and DVD video players. DVD+R/+RW drives write at 2.4X speed, recording a full DVD disc about 5 minutes faster than 2X writers. DVD+R drives and media provide a reliable, low-cost storage solution for archiving home videos, photos, mixed media presentations and data that require protection from alteration or erasure. Low-cost DVD+R media will be used with DVD+R/+RW drives and video recorders announced by HP, Dell, Philips, Ricoh and Sony.

What Works Where?

DVD Format	Typical Manufacturers	Supporting Organization	Primary Application	Compatible Media
DVD-R Authoring	Pioneer	DVD Forum	Content Development	DVD-R (A)
DVD-R/RW*	Pioneer LaCie QPS CD Cyclone	DVD Forum	Video Development, archiving	DVD-R(G) DVD-RW
DVD+RW/+R*	Ricoh H-P Philips Sony Thompson	DVD+RW Alliance (8C)	Computer, Video	DVD+RW DVD+R
DVD-RAM/R	Panasonic Hitachi LG Electronics Samsung LaCie QPS	DVD Forum	Computer, Video, Optical Libraries	DVD-RAM DVD-R(G)
DVD SuperMulti*	Hitachi Panasonic LG Electronics LaCie QPS	DVD Forum	Computer, Video, Libraries	DVD-RAM DVD-R(G) DVD-RW
DVD Multi*	LG Electronics	DVD Forum DVD+RW Alliance	Computer, Video	DVD-RAM DVD-R(G) DVD-RW DVD+RW

* **Drives also write all published CD format media**

DVD-RW - DVD-RW is officially referred to as a "re-recordable" format by the DVD Forum, but is commonly known as a rewriteable format. Available with a capacity of 4.7GB, DVD-RW media is recorded sequentially, making it ideal for streaming video applications. DVD-RW media contains protection technology that prevents copying of copyrighted content. Users can write to the disc in multiple sessions as long as the disc has not been finalized, but DVD drives and players can only read DVD-RW media after the disc has been finalized. Currently offering 1x write performance, DVD-RW discs can be overwritten 1,000 times. Most legacy DVD-ROM drives and DVD players, especially those produced in the past two years, will read DVD-RW media. Available at street pricing approaching $10.00, DVD-RW discs are used by drives and video recorders from Pioneer, Compaq, Sony and other manufacturers.

DVD+RW - Introduced in October 2001, DVD+RW is a rewriteable format developed by the DVD+RW Alliance. Offering 2.4x recording and 1,000 rewrites, the 4.7GB DVD+RW technology is used by consumers for both audio/video and data storage applications. DVD+RW incorporates lossless linking technology, allowing the drive or video recorder to accurately stop and start the writing process, or to replace individual 32kB data blocks. Lossless linking improves compatibility, performance and ease of use, and permits support of drag-and-drop applications like the Mount Ranier specification (similar to CD-RW functionality). For PC applications, DVD+RW hardware can optionally support CAV (constant angular velocity) recording to enable fast, random-access reading of the disc. With multi-session writing technology, users who have not finalized the disc can quickly add documents, data and video segments without having to open and close write sessions. By incorporating the +RW specification for defect management, manufacturers ensure that data is accurately written to and read from the disc. DVD+RW media, which is currently available for $10.00 to $15.00, is compatible with +RW drives and video recorders from HP, Philips, Sony, Dell Computer and other leading manufacturers.

DVD-RAM-DVD-RAM (DVD Random Access Memory), the rewriteable format developed by the DVD Forum, provides 100,000 write/rewrite cycles. DVD-RAM features random write/read support, so data, video and audio can be stored and accessed like a hard drive using standard drag-and-drop techniques. DVD-RAM also offers Defect Sector Management (DSM) to ensure that randomly written data is only placed in usable areas of the media and that data is accurately recovered during the read, write processes. No finalization is required, so users do not have to open and close write sessions. However, the format specifications that allow these hard-drive like features also renders DVD-RAM media incompatible with most DVD-ROM drives and set-top video players. Single-sided (4.7GB) and double-sided (9.4GB) media are available as bare discs or enclosed in a cartridge, with end-user pricing ranging from $10 to $35. DVD-RAM discs are used with drives and video recorders from Panasonic, Hitachi, Toshiba, LaCie, QPS and others.

CLV vs. CAV Recording Methods

When selecting a DVD format, the intended application (computer or AV) and the technology used to carry out the recording process should be considered. Basically, there are two recording methods: Constant Angular Velocity (CAV) which is used in high-speed access applications such as computer storage and Constant Linear Velocity (CLV) which is used in streaming video applications.

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Most magnetic disk drives use CAV storage, where the drive rotates at a constant rpm (revolutions per minute), no matter what section of the disc is being read. With the ability to provide quick random access, CAV is favored for computer and game read/write storage.

The DVD-R and DVD-RW formats use CLV technology, the mode used for the various CD formats and DVD-Video. With CLV, the drive rotates at different rpms, depending on what track of the disc the laser is reading, to maintain a constant data transfer rate. The CLV mode enables higher data transfer rates than CAV, which makes it the preferred recording mode for streaming video, but it slows access when searching for data.

DVD-RAM, DVD+RW and DVD+R offer a combination of recording solutions that make them suitable for both computer and video storage.

DVD-RAM discs use Zoned CLV (ZCLV), a combination of CLV and CAV that allows data to be transferred at a variable rate while the drive spins at a constant rate, like a hard disk.

The DVD+RW and DVD+R formats utilize sequential CLV recording to provide high data transfer rates and offer CAV as an option when random access is required

Solving Playback Issues

Pressed media (DVD-Video, DVD-ROM) is most easily read by all DVD drives and players. Write-once media, DVD-R and DVD+R, is the next most easily read. The rewriteable formats - DVD-RW, DVD+RW and DVD-RAM are more difficult to read, but -RW and +RW still have good compatibility because their formats closely resemble that of pressed media.

Compatibility problems arise when media does not meet the physical specifications for data format, recording properties, and reflectivity, typically due to poor media manufacturing procedures. When selecting a media brand, users should consider the manufacturer's reputation for quality. Archives of mission-critical information and precious memories deserve the highest quality media.

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Other problems occur because the player or drive's capabilities and firmware are marginally designed to meet minimum specifications. As DVD format specifications have been finalized, many drive and player manufacturers have enhanced their read mechanisms to improve compatibility with the various media. By making sure that the media has been qualified by the drive manufacturer, users can avoid having to deal with these types of issues.

Because DVD format specifications have been finalized at various times since 1997, it is difficult for drive, player or recorder manufacturers to completely eliminate compatibility issues for Recordable DVD media with all legacy DVD-ROM drives and DVD players. Similar problems existed in the early days of CD-R/RW technology development. Compatibility is improving; and eventually, peripheral manufacturers and users won't have to worry about the compatibility of the recordable DVD format they use to store data, videos and music.

Recognizing that no single format currently offers everything users want, drive manufacturers have introduced combination drives that support both write-once and rewriteable DVD media-DVD-R/-RAM drives, DVD-R/RW drives and DVD+R/+RW drives. By combining a write-once DVD format with a rewriteable DVD format, the drives provide a single solution for sharing and archiving on broadly compatible DVD-R or DVD+R media and the ability to use rewriteable media for files that can be edited and recycled.

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